Faculty of Engineering

DESIGN HIGH STRENGTH CONCRETE BY USING ULTRAFINE POFA AND FLY ASH AS CEMENT REPLACEMENT

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ABSTRACT

Palm Oil Fuel Ash (POFA) and Fly Ash (FA) is a waste material which posses a pozzolanic properties. The ability of this abundance is become a cement replacement in concrete production due to its properties is same with cement. POFA is a by-product that has been produced in palm oil industry, while FA is a by-product of the coal combustion. The high development in cement industry, plus the increasing in amount of these waste materials (POFA and FA) is a reason why many researchers have been focusing on this problem. A previous study by researcher prove that POFA and FA with high fineness is a good pozzolanic material and be able to improve the strength of concrete. First, a raw POFA that collect from Rimbunan Hijau palm oil mill is sieved pass through 150 µm sieves before burning process at 500 °C by using electronic kiln. The process of burning is carried out for 8 hours to eliminate the carbon content and water content inside the POFA. Sample of POFA is ground by using an electric power grinder to become a finer size (Ultrafine) with a range between 0.1 µm to 10 µm. Next is checking the particle size of Ultrafine POFA by using particle size analyzer. For FA, these samples already packaged in a bag at factory and has been provided in lab. An Ultrafine POFA and FA then is implanted in the production of the concrete mixture. Hence, this project is carried out to design high strength concrete by doing the compressive strength test on the sample. As the results, the optimum percentage of fly ash as cement replacement is 30%, which is 43.99 MPa on 56th days of the test. While, the optimum percentage of Ultrafine POFA as cement replacement is 10%, which is 51.12 MPa on 56th days of the test. Therefore, the objective of this project to design high strength concrete by using fly ash is not achieved and by using Ultrafine POFA has slightly achieved the minimum standard (55 MPa).

ABSTRAK

Abu Bahan Api Minyak Sawit (POFA) dan Abu Arang (FA) adalah bahan buangan yang memiliki ciri-ciri *pozzolanic*. Keupayaan kelimpahan ini menjadi pengganti simen dalam pengeluaran konkrit kerana sifat-sifatnya adalah sama dengan simen. POFA adalah hasil sampingan yang dihasilkan dalam industri minyak sawit, manakala FA adalah hasil sampingan pembakaran arang batu. Pembangunan yang tinggi dalam industri simen, ditambah dengan jumlah yang semakin meningkat dalam bahan-bahan sisa (POFA and FA) adalah satu sebab mengapa ramai penyelidik telah memberi tumpuan kepada masalah ini. Satu kajian sebelumnya oleh penyelidik membuktikan bahawa POFA dan FA dengan kehalusan tinggi adalah bahan *pozzolanic* yang baik dan dapat meningkatkan kekuatan konkrit. Pertama, sampel POFA yang diperoleh dari kilang kelapa sawit Rimbunan Hijau ditapis melalui tapisan 150 µm sebelum melalui proses pembakaran pada 500 °C memggunakan mesin elektronik kiln. Proses pembakaran keatas POFA dilakukan selama 8 jam untuk menghapuskan kandungan karbon dan kandungan air pada POFA. Bahan POFA dikisar dengan menggunakan pengisar elektrik kuasa untuk menjadi saiz yang lebih halus (Ultra halus) dengan saiz antara 0.1 µm hingga 10 µm. Seterusnya ialah memeriksa saiz zarah POFA ultra-halus dengan menggunakan penganalisis saiz zarah (*Particle size analyzer*). Untuk FA, bahan ini telah tersedia dibungkus di kilang dan telah tersedia di dalam makmal. Kemudian, bahan POFA ultra-halus dan FA digunakan dalam penghasilan campuran konkrit. Oleh itu, projek ini dijalankan untuk mereka bentuk kekuatan tinggi konkrit dengan melakukan ujian kekuatan mampatan pada sampel. Hasilnya, peratusan optimum abu arang sebagai pengganti simen adalah 30%, iaitu 43.99 MPa pada hari ke-56 ujian. Manakala, peratusan optimum POFA Ultra halus sebagai pengganti simen adalah 10%, iaitu 51.12 MPa pada 56 hari ujian. Oleh itu, objektif projek ini untuk reka bentuk konkrit kekuatan tinggi dengan menggunakan abu arang tidak dicapai dan dengan menggunakan POFA Ultra halus sedikit mencapai had minimum (55 MPa).

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CHAPTER 1

INTRODUCTION

1.1 Background

According to Taylor et al., (2006) the cement industry becomes the second largest producer of the greenhouse gas. Nowadays, approximately 1 ton of cement has been produced each year for every human being in the world (Reno et al., 2013). Therefore, the right way to protect the environment and this negative issue, the main concern of minimizing CO_2 emission can be realized by reducing the percentage of cement used in concrete mixtures.

In order to curb the negative environmental impacts and disintegration of the concrete structure, many researchers have been focusing on developing more sustainable cementitious systems. Several attempts have been made to develop a sustainable binder through the use of pozzolans such as palm oil fuel ash (POFA), fly ash (FA), risk husk ash (RHA), slag and any other waste materials with a relatively larger amount of replacement of cement (Hossain et al., 2016).

According to Johari et al., (2011) the major agro industries in Malaysia and Thailand is palm oil industry and this industry produces a large amount of waste in the forms of empty fruit bunches, fibers and kernels. The ash derived from tbe process of heat up the boiler for the generation of electricity in palm oil factories has been known as POFA (Awal and Hussin, 1997). Reported by MPOB (2009) that approximately 3 million tons of POFA were produced throughout Malaysia in 2007. Hence, realizing the vast quantity of POFA produce every year and may contribute to the environmental problem, many researchers have attempted to utilize POFA as a pozzolanic mineral admixture in concrete.

Next, waste materials have been focus is fly ash. Electricity power plants will produce high quantities of fly ash as a byproduct of the coal combustion. Reported by Jow et al., (2015) that 777 million tons of FA were produced globally in 2008 and only 54% was utilized. The huge amount of FA will cause a negative issues such as dust, air pollution and the damage to the ecological environment (Wang et al., 2016). Therefore, using of the high volume of cement replacement in concrete with FA will be highly beneficial with respect to energy efficiency, overall ecological and environmental benefits, low permeability and durability (Arezoumandi and Volz, 2013).

The worldwide use of cement concrete has a problem causing significant negative influence on construction and infrastructure, increasing the related fee and shortening the life span. According to Husem and Gozutok (2005) that many researchers have been focus to design high strength concrete, especially after a lot of deteriorating phenomena were recorded and investigated. Production of high strength concrete may or may not require special materials, but it requires the highest quality of materials and their optimum proportions (Carrasquillo, 1985).

By using POFA and FA as a cement replacement in concrete, it is possible to design a high strength concrete. The high strength concrete can be advantageously used in compression members like column and piles. It also results in a reduction in column size and increases available floor space (Rashid, 2008).

1.2 Research significance

In constructions, cement becomes most useful binding materials. However, the high development in cement industry nowadays which will contribute to the producing of greenhouse gas and also global warming. By using POFA and FA as partial cement replacement would be the right solution in order to overcome the environmental impacts and disintegrate of cement production.

A previous study from many researchers has been discovering the advantage of using POFA and FA as cement replacement. Previously, it had been proven that these POFA and FA with high fineness is a good pozzolanic material. Furthermore, the high fineness of POFA and FA that will use as partial cement replacement can improve the properties of concrete production and become more workability and high strength. However, previous studies not achieved to design high strength of concrete by using these waste materials. The strength is better than normal concrete, but not reached the minimum standard for high strength concrete which is 55 MPa.

Hence, this study will discover the right mix design and the compressive strength to produce high strength of concrete. Plus, it will help in reducing the waste material by using them in concrete structures. The significance of this study becomes a good alternative to overcome construction problems by producing high strength of concrete.

1.3 Problem statement

Previous researchers proved that POFA and FA with high fineness percentage could increase the compressive strength of the concrete. The strength can be higher than normal concrete, but not achieved the high strength concrete standard. Therefore, studies need to be conducted to investigate high strength concrete by using POFA and FA as cement replacement.

This study will find the suitable mix design in producing a concrete mixture and focusing on the percentage of POFA and FA as cement replacement that will contribute to high strength of concrete.

1.4 Research Aim and Objective

The aim of this research is to design a high strength concrete by using POFA and FA as cement replacement.

The specific objectives of this research are described as follows:

1. To determine the concrete mixed design of high strength concrete, and
2. To determine the compressive strength of the concrete mixture.

CHAPTER 2

LITERATURE REVIEW

2.1 Ordinary Portland cement (OPC)

Cement is the most useful binding construction material. A workable paste after mixing it with water has the ability to harden in the air and under water. According to Gao et al. (2015) buildings, industrial construction, infrastructure facilities, dams, road or bridges that surround us have been created with cement.

The first inventor of Portland cement is through to be Joseph Aspdin in 1824, who was granted a patent on the process of obtaining a binder created from a roasted mixture of limestone and clay. During that time also the name "Portland Cement" has been used. By firing the calcium carbonate contained in the stone until its total decomposition will obtain the binder. The process was carried out at a relatively low temperature. After numerous attempts, Isaac Johnson established the correct proportions of limestone and clay in 1845 and often considered to be the inventor of the modern Portland cement (Huntzinger and Eatmon, 2009). Johnson created roasting at a higher temperature, which enabled the formation of compounds of good binding properties.

Since a relatively simple technological process of cement production, it has led to a rapid development of the cement industry in Europe and the USA in the second half of the 19^{th} century. The production of cement increased, most rapidly after World War II. The global cement production reached 134 million Mg in 1950, 832 million Mg in 1980 and at present it exceeds 1600 million Mg (Kurdowski, 2010)

2.1.1 Type of cement

According to Dogan and Ozku (2015) 5 types of cement which are normal Portland cement (CEM I 42.5 R) and four pozzolan cements (Portland composite cement CEM II/A-P 32.5, CEM II/B-P 32.5 and CEM II/B-M 32.5 and Portland pozzolanic cement CEM IV/B-M 42.5). It was obtained from different resources and used in the production of concrete. Table 2.1 shows the chemical and pozzolanic composition and physical properties of cements.

Table 2.1: Chemical and pozzolanic composition and physical properties of cements (Dogan and Ozku, 2015)

	Type I	Type II	Type III	Type IV	Type V
Pozzolan contents	-	15% Natural Pozzolan	10%Natural Pozzolan, 15% Fly Ash	35% Natural Pozzolan	25%NP, 15%FA, 5% LF
Chemical composition (%)					
SiO_2	20.16	28.24	30.13	35.81	34.96
Al_2O_3	5.12	6.61	8.77	8.57	9.80
Fe_2O_3	2.92	3.04	4.11	3.29	4.52
CaO	63.87	55.14	49.34	43.89	4-.01
MgO	1.81	1.69	1.72	1.63	1.92
SO_3	3.03	1.43	1.38	1.37	0.87
K_2O	0.65	0.84	1.17	1.19	1.25
Na_2O	0.23	0.58	0.56	1.21	0.69
LOI	2.12	1.73	2.56	2.29	4.04
Insoluble	0.58	10.70	7.57	24.97	18.35
Physical properties					
Specific gravity	3.14	2.99	2.92	2.76	2.75
Fineness Blaine (m^2/kg)	312	295	355	328	398

2.2 Waste material as partial cement replacement

Over the past few decades, a lot of industrial waste materials like fly ash, slag and various agricultural wastes such as groundnut husk ash, millet husk ash, POFA, and corn cob ash have been tried as secondary cementitious materials or pozzolanic. At a certain proportion, these waste materials become a significant role when mixed with the cement.

According to Adole et al. (2012), these waste materials mention was able to minimize the permeability of concrete by altering the pore structure, and the resulting concrete shows a significant resistance against reinforcement corrosion, sulfate attack, and acid attack. Reported by Shiathas et al. (2003), these pozzolanic materials such as ground granulated blast furnace slag, pulverized fuel ash, fly ash, POFA generally improve durability properties and reduce adverse environmental effects.

In 2008, results of corrosion resistance and chloride ion penetration test on mortar specimens made up of binary blends of OPC and ground POFA or ground RHA revealed that the blended POFA or RHA with OPC could significantly improve corrosion and chloride resistance (Rukzon, 2008). Therefore, these materials have high potentials to be used in the concrete industry.

Due to increasingly stringent environmental legislation, using waste materials as partial cement replacement will help to overcome negative environmental issues and disintegration of tbe concrete structure.

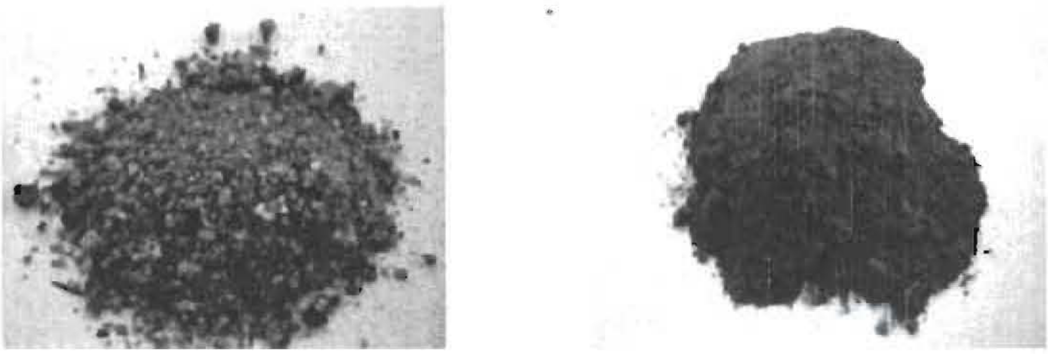
2.2.1 Palm Oil Fuel Ash (POFA)

Several studied have been done to find alternatives that can be used as cement replacement. These studies, including the disposable and less valuable wastes from industry and agriculture, whose potential benefits can be realized through recycling, reuse and renewing programs. Hence, an investigation by researchers about the effectiveness, availability, and efficiency of waste materials that are pozzolanic in nature as cement replacement. The required waste materials should be rich in silicon (Si) and aluminium (Al).

According to Tangchirapat et al. (2007), POFA contains high amounts of silicon and aluminum oxides in the amorphous state. The addition of POFA as pozzolan in concrete increased the compressive strength as well as reducing the permeability of water. Reported by the Tay and Show (1995) the used of POFA as a replacement of cement material revealed that the workability of concrete is good and no segregation was observed.

Malaysia has been the second largest palm oil plantation after Indonesia. According to Jumaat et al. (2009) 7 million tons of crude palm oil produced in Malaysia each year, while 100000 tons of POFA produced in Thailand annually (Jaturapitakkul, 2007). The generally used of a palm tree in commercial agriculture resulted in increasing the development of palm tree plantations.

POFA has been produced from incinerated waste in the boiler. A plenty of waste that obtained from palm oil processing for oil extraction, such as palm fibers, nut shells, palm kernels and empty fruit branches (Zarina, 2013). POFA has obtained byproduct from a power plant that generates electricity, which used the shell, palm fiber, and empty fruit bunches and burnt at 800 -1000 C (Kroehong, 2011). Meanwhile, the hoiler ash is by burning the kernel shells and palm fibers in the boiler where it consists of clinker and ash (Subramaniam, 2008).



(a) (b)

Figure 2(a): Original boiled ash, (b) Original POFA (Zarina,2013)

The burn of empty fruit bunches to produce energy will produces about 5% ash by weight of solid waste (Aprianti et al., 2015). These materials produced are rarely used means, posing a bad issue through the concomitant pollution of the environment. Appropriate ways to reduce the problem, both ashes have been utilized in many applications such as cement replacement for the production of concrete (Johari et. al., 2011) wastewater treatment and air purifier in cleaning atmospheric contaminants (Dahlan et al., 2007).

2.2.2 Properties of POFA

According to Ranjbar et al. (2014) both of the materials which are POFA and OPC have an agglomerated particle shape, while the OPC has a less porous structure compare to the POFA. The physical characteristic of POFA is usually influenced by the operating system in the palm oil factory. As shown in Table 2.2 and 2.3, the physical and chemical composition of POFA and OPC.

Table 2.2: Physical properties of OPC and POFA (Ranjbar et al., 2014)

Property	OPC	POFA
Maximum size (mm)	-	-
Water absorption (%)	-	-
Fineness modulus	-	-
Passed from 45m sieve (%)	91	96
Median particle size, d50	14.6	10
Specific Gravity	3.15	1.81

Table 2.3: Chemical analysis of the OPC and POFA (Ranjbar et al., 2014)

Chemical composition	OPC (%)	POFA (%)
SiO_2	17.60	64.17
Al_2O_3	4.02	3.73
Fe_2O_3	4.47	6.33
CaO	67.43	5.80
MgO	1.33	4.87
Na_2O	0.03	0.18
K_2O	0.39	8.25
SO_3	4.18	0.72
$SiO_2 + Al_2O_3 + Fe_2O_3$	-	74.24

According to Aprianti (2014) the ash produced is greyish and darker in colour based on its carbon content. The burn carbon will produce a whitish grey of POFA. The main oxide of POFA is SiO2 that explained POFA rich in silica content compared to the OPC. Therefore, the abundance of PFA concomitant with silica rich characteristics paves the way for its usage as partial cement replacement. The amount of the chemical components on POFA is different due to the material source, burning process and efficiency.

2.2.3 Pozzolanic reaction of POFA

The reaction between SiO_2 and Al_2O_3 in a pozzolanic material with $Ca(OH)_2$ will gain the formation of calcium – silicate – hydrate or C – S – H in cement paste. The $Ca(OH)_2$ was used as an indicator in pozzolanic reaction. According to Chindaprasirt et al. (2005) the increasing portion of the pozzolanic replacement and fineness will cause a reduction in the $Ca(OH)_2$ content but, improving the sulphate resistance in concrete.

High fineness of POFA has a faster pozzolanic reaction than coarse POFA (Chindaprasirt et al, 2005). Therefore, POFA be able to improve the compressive strength of concrete due to its high fineness which is more homogenous and denser. Reported by Jaturapitakkul et al. (2011) the compressive strength of mortar due to the pozzolanic reaction of POFA for 10 – 40% replacement of cement by weight of binder varied from 0.1 MPa to 4.5MPa at 7 days and 2.5MPa to 22.5MPa at 90 days. Based on the result, it shows that the pozzolanic reaction on POFA is small at an early age and increase in significance at a later age.

2.2.4 Compressive strength of POFA

On the early research of POFA, the used of POFA in concrete indicates the POFA in its original form has low pozzolanic properties. The replacement of POFA may not more than 10% of cement mass for the concrete or mortar production (Tay, 1990). A study by Muthusamy (2015) have stated that the 20% of POFA as cement replacement gave the maximum compressive strength of concrete and the replacement of POFA with cement up to 50% could still be used for the structural application. From early research of POFA also highlight that the limitation of POFA when used in high strength concrete, that could be mainly due to the coarser particle size, high content of carbon and greater loss on ignition of untreated POFA. According to Zeyad (2016) the use of POFA as cement replacement can improve its fresh properties such as workability due to more paste volume, delay in slump loss and hardening properties. The compressive strength can achieve more than 90 MPa on the 28^{th} day of the test. The used of Superplasticiser (Sp) on the research contribute to achieve high strength concrete.

2.2.5 Fly Ash (FA)

According to Chousidis et al. (2016) a reduction in concrete permeability and porosity is strongly encouraged to avoid chloride attack. A relative inexpensive techniques to overcome the problem and protecting the reinforce concrete from chloride attack is the utilization of waste materials as a replacement of cement. By using fly ash in concrete may produce C–S–H bonding and lead to improved concrete performance.

Increases of world economic resulted in the demand for energy, which many countries are produced by using coal combustion. From the coal combustion, it generated 29.9% of the world supply electricity, while world wide consumption of coal is planned to increase by 36% by the year 2020 (Jala and Goyal, 2006) and 46% by 2030 (Yao et al., 2014).

Electricity power plants will produce high quantities of fly ash as a byproduct, which the quantities are estimated globally at 750 million tonnes annually. According to Yao et al, (2014) there are 2 types of fly ash, which is the coarse bottom and fine fly ash. It is because the ashes produced by burning of bituminous, anthracite, and lignite coals contain different amount of calcium, silica, iron and aluminum. According to Ukwattage et al, (2013) the ashes have been grouped into two classes which are class C and F. The burning of lignite will produce ash belong to class C and contain 12 – 25% of CaO while ash produced from anthracite belongs to class F and contains less than 10% of CaO.

The burning of lignite exhibit alkaline properties because they contain hydroxides as well as Ca and Mg carhonates (Ahmaruzzaman, 2010). According to Miralles et al. (2002) fly ash also contains a high amount of soluble salts that contribute to their high electrical conductivity. It will increase salinity and may cause a negative issue in the soil environment.

Next. fly ashes generate from the burning of lignite have a different amount of nonburnt particle due to low of nitrogen content.

2.2.6 Properties of FA

Chemical and physical properties of fly ash are differentiated based on the source of coal and the way to burn the coal. Fly ash with low-calcium content is grouped into Class F while, high-calcium content is grouped into Class C. From the coal fired thermal plants, it created tremendous volumes of coal ash, which comprises of bottom ash and fly ash. Table 2.4 and 2.5 shows the physical properties of fly ash and cement and chemical composition of cement and coal fly ash (CFA).

Table 2.4: Physical properties of fly ash and cement (Hafiz et al, 2016)

	Cement	Fly ash
Fineness retained on 45 um (%)	-	32
Specific gravity	3.15	2.75

Table 2.5: Chemical composition of cement, CBA and CFA (Rafiezonooz et al, 2016)

	Cement (%)	CFA (%)
SiO_2	20.4	47.6
Al_2O_3	5.20	23.8
Fe_2O_3	4.19	7.42
CaO	62.39	10.7
MgO	1.55	1.50
Na_2O	-	2.16
K_2O	0.005	1.68
TiO_2	-	2.92
P_2O_5	-	1.16
MnO	-	0.120
SO_3	2.11	0.759

Fly ash is finer than cement. According to Zhao et al. (2015) fly ash may affect the properties of blended cements and thus concrete hydration. The percentage of Iron oxide (Fe_2O_3) of FA is higher than OPC, and hence it had a darker colour than OPC (Kupaei et al., 2013). From the Table 2 showed that CFA is mostly composed of Silica, Alumina and Iron. The percentage of the three composition mention is about 78.82% showing that it is a Class F according to ASTM C618-05 (2005).

2.2.7 Pozzolanic reaction of FA

According to Kouloumbi et al, (1994) replacement of cement by using fly ash leads to a reduction in free chloride concentration. FA concretes will show lower corrosion rates of reinforcement steel compared with OPC concretes. Next, fly ash is able to improve the long term compressive strength of concrete (Chousidis et al., 2015). It is due to a reduction in its porosity, while the reaction of $Ca(OH)_2$ (C-H) with FA drying shrinkage of the composite material and decreases the hydration heat release. The pozzolanic reaction of fly ash is described on the formation of calcium silicate hydrate (C-S-H). The reactions are shown in equation 1 and 2 (Chousidis et al, 2016).

$$Ca(OH)_2 + H_4SiO_4 \longrightarrow Ca^{2+} + H2SiO_4^{2-} \quad (1)$$

$$Ca^{2+} + H_2SiO_4^{2-} + 2H_2O \longrightarrow CaH_2SiO_4 \,.\, 2\, H_2O \quad (2)$$

The chloride binding capacity in cementitious systems is lead by the content of C_4AF and C_3A The formation of Friedel's salt has happened when chlorides are bound by the C_4AF and C_3A. Equation 3 showed the formation of Friedel's salt According to Suryavanshi (1996) the need for the Freidal's salts is to remain stable during the service life of a concrete structure contaminated with chloride. In fact, addition of fly ash raises the aluminum silicate phase (C_3A) of the cementitious material, reducing concrete porosity and consequently increasing the rate of Friedal's salt formation.

$$2Cl^- + 3CaO\ Al_2O_3\ CaSO_4\ 10H_2O \longrightarrow 3CaO\ Al_2O_3\ CaCl_2 10H_2O + SO_4^{2-} \quad (3)$$

2.2.8 Compressive strength of FA

As the FA are used in the mixture of concrete, it may reduce the amount of cement required and thereby reduces greenhouse gas emissions and effectively recycle fly ash as an industrial byproduct. According to the research by Sengul et al., (2005) the effect of the replacement of cement hy FA from 10% to 70 % show that the compressive strength of concrete is lower at 28 days but a higher strength over longer periods. The result has been compared with the normal concrete. Another research about replacement of cement using FA has been done by (Wang et al., 2015). In this research stated that the compressive strength is less than the control concrete at an early age. At a later age, for the low volume of FA as cement replacement (15% to 25 %) the compressive strength can surpass the control concrete. While for the high volume of FA as cement replacement (45% to 55%) the compressive strength cannot surpass the control concrete.

2.3 High strength of concrete

2.3 1 Normal Concrete

Concrete is the most used construction material in the huilding industry and consumes the second highest amount of natural resources. The main constituents of concrete are cement, water and aggregates. A report by the United States Geological Survey (2015) shows that global cement production increased to a total of 4.18 billion tonnes in 2014. This cement consumption trend is able to increase in the future (PCA, 2015).

Concrete is becoming a popular material because it has a very good mechanical and durability properties. It is also adaptable, relative fire resistance, generally available and affordable to buy. According to Robati et al. (2016) concrete can absorb and retain energy for a considerable period of time. By transferring heat through the structural component, this action may reduce energy consumption. The mass components reduce the temperature in huilding spaces and therefore reduce the associated peak heating and cooling loads (Deo and Neithalath, 2011).

As mentioned the basic constituents of concrete are cementitious materials, coarse and fine aggregates and water. The properties of the in-situ concrete is determined from the properties of this material, their combination, the effects of various admixtures and how it is handled during construction (Robati et al., 2016).

2.3.2 Introduction of high strength concrete

The worldwide use of cement concrete has a problem causing significant negative influence on construction and infrastructure, increasing the related fee and shortening the life span. To overcome this weakness, many researchers have been focus to design high strength concrete, especially after a lot of deteriorating phenomena were recorded and investigated (Husem and Gozutok, 2005). Moreover, The pile foundation or base of buildings is often designed by using ordinary concrete, so its properties are important because may affect the infrastructure workability and safety significant. So the improvement on ordinary concrete needs to be the primary.

According to Libre et al. (2010) many engineering designers have taken the concrete workability and resistance into consideration, they have mixed polymers to improve the density and viscosity making it some sort of waterproof and sprayed hydropbobic agent making it hard to be wetted from the external surface by the moisture outside. However these external methods will encounter the aging and flaking problem after a long life span.

In 1950, concretes that have 30 MPa compressive strength were considered to be high strength. However now, the strength regarded as a low strength. Gradually, concrete that has a compressive strength from 40 to 100 MPa have been used in practical structures starting in the year 1960 until 1980 (Rashid and Mansur, 2009). Reported in the North American practice (ACI 318, 1999) minimum cylinder compressive strength of high strength concrete is at least 41 MPa at 28 days while, a report by FIP/CIB (1990) that high strength of concrete is defined as concrete that is having a 28 day cylinder compressive strength of 60 MPa. According to Ertekin et al., (2015) the range strength of normal strength concrete and high strength concrete are from 20 MPa to 55 MPa and 55 MPa to 85 MPa respectively.

According to environmental issues that occur in this decade, the concrete industry is replacing the use of cement and other components that are associated with high CO_2. From several studied, there are possible to replace of cement in concrete with recycled materials to